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ABSTRACT

Eight 2-month-old Japanese infants and their 25- to 30-year-old mothers participated in an investigation of the characteristics of pleasure vocalization, correlations in pitch and duration between motherese and pleasure vocalizations, and similarities in the melody types of motherese and pleasure vocalizations. Motherese, infant vocalizations occurring in response to it, and the mothers' responses to infants' vocalizations were analyzed by sound spectrograph. Sound spectrograms of the vocal sounds of the infants and the mothers were classified according to the scheme used by Wasz-Hockert and others (1968). Findings indicated that, as a general tendency, pitch agreement was seen in each mother-infant pair. Mothers replied to the high-pitched voices of their infants in a higher pitch than usual, as if they were influenced by the vocalization pitch of the infants. No individual differences were observed in the duration of infants' vocalizations. There was a marked individual difference in the duration of phrases uttered by mothers. No large difference was observed in infants' vocalization latency after mothers' speech. Latency of mothers' response to their infants' vocalization differed greatly. Rising-falling and flat patterns were dominant melody types of infants' pleasure vocalizations. The melody type of motherese differed by individual, with the rising type of melody predominating. (RH)

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Mother-Infant Interaction as an Original Point in Music Education

-- Spectrographic Studies on the Pleasure Sign of Two Month-old Infants --

by Yoko Shimura

It has been established scientifically that the neonate reacts readily to phonetic sounds, especially to the voice of its mother. Moreover, it has been reported that both neonates and young infants interact with their mothers through phonetic sounds. In other words, the infant reacts to the parent's "motherese" (Schaffer et al. 1964) and responds by facial expression, body movement, or vocalization (Melzoff et al. 1977, Field et al. 1982). The mother responds to this in turn (Fernald 1984).

It has become clear that such mother-infant interaction induces mutual reaction and thus builds up very close bonding. It is also clear that in intensifying this bonding, mother-infant "conversation" (that is, "vocal interaction") in the infant's early days is most significant.

When a young infant is watched closely, vocalization different from a cry is observed as early as at the end of the first month or early in the second month. This phenomenon is popularly called "vocal play" or "babbling", and it is

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generally thought that the infant is enjoying himself by uttering a sound. This is also believed to be the foundation for eventual language learning. Many mothers have noticed that infant vocalizations occur more often when the level of mother-infant interaction is enhanced, which occurs when the baby is in a state in which he feels very pleased. The infant's vocalization is a sign of pleasure, and it has great significance as his non-behavioral reaction to the mother's various approaches.

The infant's primitive pleasure vocalization is of great interest in learning about his phonetic sounds and the development of his vocalization. It is, therefore, very meaningful to study the results of acoustic analysis of the infant's vocalization in relation to the pitch, intonation and duration of motherese.

Motherese, which plays a role in stimulating the infant's vocalization, is equally important. Motherese spoken by the mother is essential in making the infant feel pleased. Her motherese and baby talk contain not only elements of verbal meaning and content but also acoustic elements such as the voice's tonal color, rhythm, melody, dynamics and agogic. These are musical elements and are considered to provide a special acoustic environment to the infant, as Fernald et al.

pointed out. The amount of pitch excursion is unique to motherese.

The infant period is a time when the infant reacts particularly sensitively to sound. If mother-infant communication via voice in this period is considered as the foundation of musical experience and the starting point of music education, motherese and baby talk can be regarded as constituting a musical environment. If the mother repeatedly talks to the baby in short words with rich intonation and tries to synchronize her pitch with the pitch of the infant's vocalization, this not only helps establish mother-infant interaction but also provides a solid foundation for the infant's future music experience.

On the basis of the viewpoint above, we studied mother-infant interaction as the starting point of the development of musical behavior of a young infant. In pursuing this study, we conducted acoustic analysis of the voices of the mother and infant, uttered while in a state in which mother-infant interaction has been established, by using babies between 50 and 70 days old who usually engage in pleasure vocalization. From the standpoint of mother-infant interaction, we studied the characteristics of pleasure vocalization, correlations in pitch and duration between motherese and pleasure vocalizations, and similarities in the melody types of motherese and pleasure vocalizations.

o Method and Subjects

We selected eight two-month-old infants and their mothers for this study. First, the vocal communication between the mothers and infants was recorded on tape. After removing physiological sounds (breathing, coughs and sneezes), the recorded voices were acoustically analyzed with a sound spectrograph.

The mothers selected for this study were the principal rearers of the infants selected, and they were between 25 and 30 years old when they gave birth to the infants. They were either senior high school or university graduates. (Table 1)

In order to record the infants' voice, we visited the home of each infant either in the morning or afternoon and recorded their voice while staying there for two hours.

The recording was done 20 to 30 minutes after the infant was fed and his diaper was changed and while he was fully awake, either in the mother's arms or lying in bed. The recording was taken after it was confirmed that eye-to-eye contact between the infant and its mother had been established and that the baby was feeling very pleasant. In conducting this experiment, the author took great care not to disturb the mother-infant relation. No effort was made to control the voice communication between the mother and infant and the recording was made in a natural state. The microphone

was placed 15-20 centimeters away from the infant's mouth so that it would not be a visual distraction. Out of the recorded voices of the eight mother-infant pairs (each recording lasted about 30 minutes), one section where the mother and infant's phonetic sounds were most concentrated (three minutes each) was taken out for spectrographic analysis.

In recording the sounds, a SONY-D5M tape-recorder and a SONY F770 dynamic microphone were used.

o Method of Analysis

From the recorded sounds of eight mother-infant pairs, we selected motherese, infant vocalizations that occurred in reaction to the motherese, and the mother's response to the infant's vocalizations and analyzed them with the sound spectrograph.

Sound spectrograms of the vocal sounds of the infants and the mothers were classified according to the scheme used by Wasz-Höckert et al.

The sound spectrograph used for this study was a RION SG-07 model. The recording time of the samples for analysis was 2.4 seconds, and the bandwidth covered was therefore 8kHz. High frequency pre-emphasis was used. The VU meter peaked in the -5 to -3 range.

o Results

The following is the report on the results of analysis made with the sound spectrograph.

(1) Fundamental Frequency (Fo)

In making the analysis, the infant's vocalization from the end of the preceding inspiration to the beginning of the next inspiration was regarded as one "phonetic sound", and its fundamental frequency will be referred to as "pitch". Vocal fry sections were not measured. (Fig. 1)

The Fo of the eight infants averaged 317.5 Hz, ranging from 241.8 Hz to 464.6 Hz. (Table 2)

In analyzing the fundamental frequency of the mothers' phonetic sounds, one phrase was regarded as one phonetic sound and its fundamental frequency was analyzed.

The Fo of the eight mothers was 278.3 Hz on the average, ranging from 180.6 Hz to 381.8 Hz. (Table 2)

The correlation coefficient for Fo of the eight mother-infant pairs was 0.87 ($p < 0.01$), which represented a high correlation. The correlation was observed in two mother-infant pairs as a result of analysis of the extracted mother's phrase and infant's vocalization which immediately followed. (Pair F*; $r=0.51$ ($p < 0.05$), Pair H: $r=0.71$ ($p < 0.05$).)

* Each capital letter identifies a particular mother-infant pair.

(2) Duration

The analysis of the duration of infant vocalizations was conducted by regarding the time from the end of the preceding inspiration to the beginning of the next inspiration as one phonetic sound. The average duration was 0.44 seconds, ranging from 0.30 seconds to 0.59 seconds. There was not much difference in duration among the eight infants. (Table 2)

The analysis of motherese was conducted by regarding one phrase as one phonetic sound as in the case of Fo. When breathing took place in the middle of one phrase, the phrase was divided into two parts and each part was analyzed independently. The average duration of motherese was 0.69 seconds, ranging from 0.28 seconds to 1.09 seconds. There was a large difference in duration among the eight mothers. (Table 2)

No mother-infant correlation was observed in duration ($r=-0.09$). High correlation was observed only in one mother-infant pair. (Pair B: $r=0.89$ ($p>0.001$))

(3) Latency

"Latency", as used in this study, is different from the latency normally measured in studying the infant cry, such as that between pain stimulation and cry. In this study, the interval from the end of the motherese to the beginning of the infant's vocalization was regarded as "latency". The numerical values listed for the infants represent the length

of time between the end of the mother's phrase to the beginning of the infant's vocalization. The average latency of the eight infants was 1.15 seconds, ranging from 0.32 seconds to 2.73 seconds. (Table 2)

The mothers' latency was similarly analyzed. In other words, the time between the end of the infant's vocalization and the time the mother began to utter words was measured. The latency was 3.23 seconds on the average, ranging from 0.38 seconds to 12.63 seconds. Differences between individuals were greater in the case of mothers than in the case of infants. (Table 2)

The mother-infant correlation coefficient for latency was $r=0.55$ ($p<0.2$).

(4) Melody Type

Each vocalization of the infant and one phrase of the mother's words were classified into the intonation patterns shown in Table 3. We use the term "melody type" to refer to patterns of fundamental frequency variation, with the type categorized by the direction of the final variation of the vocalization. The results of the analysis are shown in Table 4.

The melody types of the infant vocalizations were mostly flat or falling type, with few rising type. Only one infant showed the falling-rising-falling pattern, but this type was

not found in other infants' vocalizations. Melody types classified as "Unclassified" were falling-rising-falling-rising and rising-falling-rising-falling patterns.

There was a large difference among individuals in the melody type of the mothers' phrases. Most phrases uttered by three mothers were flat, more than half of the phrases uttered by one mother were of the rising type, more than half of the phrases uttered by another mother were of the falling type. On the average, however, phrases uttered by eight mothers were almost equally divided into the flat type, rising type, and falling type.

The correlation coefficient of the mother-infant melody types was $r=0.56$ ($p< 0.2$), with no conspicuous correlation observed. However, high correlation was observed in three mother-infant pairs. (Pair F: $r=0.72$ ($p< 0.05$); Pair G: $r=0.77$ ($p< 0.001$); Pair H: $r=0.71$ ($p< 0.05$)).

(5) Other Characteristics

Characteristics observed from the sound spectrographs of the infant vocalizations were classified into the following: glottal plosive, vocal fry, subharmonic break, shift, nasality, glide, and others. Phonetic characteristics of the pleasure vocalizations of the infants analyzed will be explained in detail in a separate paper.

o Discussion

A high correlation was found in the eight-pair average value of the fundamental frequency of the infants' vocalizations and that of the mothers. As a general tendency, pitch agreement was seen in each mother-infant pair. If the voice of the mother was high-pitched, the voice of her infant was also high-pitched. On the other hand, if the mother's voice was low-pitched, her infant's voice was low-pitched, too. In two mother-infant pairs especially, correlation in fundamental frequency was observed in every phonetic sound. We noticed that phrase-to-phrase changes in the fundamental frequency of the mother's voice influenced that of their infants' vocalizations, although this was seen in only two pairs.

As was mentioned at the outset, Fernald et al. found that one of the characteristics of motherese is a high fundamental frequency. Although there was a difference from one mother to another, we noted that, as if influenced by the vocalization pitch of the infants, mothers replied in a higher pitch than usual. One of the important factors in making mother-infant interaction closer is for mothers to speak or reply to their infants at a pitch synchronized to the pitch of their infants' vocalizations.

Harmonics higher than Fo and F_1 observed in the infants' vocalizations were smooth, showing no irregular wavering. The harmonics were formant-like and appeared as vowel-like sounds. Their fundamental frequency was smooth and showed vowel-like spectrum. These findings are the same as the results pointed out by Sander et al.

No individual differences were observed in the vocalization duration of the infants surveyed. This is considered due to the fact that there is not a large difference in the duration of vocalization which infants aged 60 to 70 days can utter at one breath. The average length of 0.44 seconds is conspicuously short as compared with the average 1.1 seconds of the pleasure cry reported by Wasz-Höckert et al. This, however, is considered due to the fact that our observation was conducted exclusively on two-month old infants and did not include any older ones.

There was a marked individual difference in the duration of phrases uttered by mothers. Some mothers talked to their infants in short words, while others talked to their infants in a sentence consisting of long phrases. Because the number of mother-infant pairs surveyed was limited, no correlation was observed between the duration of motherese phrases and the duration of the infants' vocalizations.

No large difference was observed in the vocalization latency of the eight infants that occurred after the mothers

spoke to them. However, the latency of mothers' response to their infants' vocalization differed greatly from one mother to another. Some mothers were very quick in responding to their infants' vocalization, while others were slow. The latency of the mother of twin infants differed when she responded to one of the twins than to the other, though the mother was one and the same person. Though this was not mentioned earlier in the "Results" of the analysis, when the mother's latency was slow, the number of phonetic sounds uttered by her infant decreased (Pair C). However, even if the mother's latency was quick, the number of phonetic sounds uttered by her infant did not increase (Pairs H & F), but the tendency was observed that the number of phonetic sounds uttered by the infants increased when the mother's latency was of a certain similar length. This is a very important point which cannot be overlooked. We intend to study this point further in the future. It can be said that mother's response to her infant's vocalization in proper timing is one of the factors that can stimulate mother-infant voice communication.

The rising-falling and flat patterns were dominant among the melody types of pleasure vocalizations of the infants surveyed. In particular, the falling type, in which the latter part of the vocalization falls, accounts for more than half of all the melody types observed. The flat type was observed in 27% of all vocalizations. This result was the

same as that obtained by Sander et al. and Wasz-Höckert et al. When compared with the melody types of cry, it is evident that the flat type dominates.

As a result of the study of the cry of three-month-old infants conducted by Thodèn et al., the flat type was seldom observed. In the studies conducted by Michelsson et al., falling and rising-falling types accounted for 85% of all vocalizations. In short, it may be concluded that one of the characteristics of melody types of pleasure vocalizations is that many are of the flat type.

The melody type of motherese differs according to the mother. So, it is difficult to identify a characteristic common to all mothers. However, in comparison with the melody type in infants' vocalizations, the rising type is predominant in motherese. This is in agreement with the characteristic of motherese mentioned by Fernald et al. Motherese surveyed in this study was classified into three types. It cannot be said for sure that the melody types of motherese definitely influenced those of the vocalizations of the infants. It cannot be said either that changes in the melody type cause changes in the infants' vocalization. However, in three mother-infant pairs, similarity was observed in the melody type of motherese and that of their infants' vocalization. Thus, influence of motherese was observed in infants' vocalizations.

This study did not go so far as to measure the range of rising or falling. Melody types were simply classified into different types. We intend to study the range of rising, changes in pitch, and pitch excursion in the future.

Various studies conducted in the past on motherese have clarified linguistic characteristics regarding such factors as accent, syllabification and pitch. However, because motherese includes such musical elements as tonal color of the voice, pitch and dynamics as well as melody and rhythm of language, it is possible, from the standpoint of music education, to think that motherese constitutes a musical environment.

Our study has observed individual differences in motherese, but we believe that there is a type of motherese which can give a stronger impression to infants as for example through the synchronization of pitch and the raising of pitch at the end. It might be said that one future task is to find motherese that not only makes it possible for the infant to enjoy vocalization but also stimulates its vocalization. It is conceivable that motherese will influence the musical sense or the development of musical behaviors of the infant (Papousek et al. 1981). Therefore, the longitudinal study of motherese from the standpoint of music will assume increasing importance in the future.

Vocal exchange between the mother and the infant is a communication and play which is conducted via vocalization in a state where the mother and infant share a good feeling. From the standpoint of music education, this can be described as the interaction of singing between the mother and the infant.

In this sense, we believe this study is a probe into the original point of music education.

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table 1

mother-infant pair	sex of infant	age in days	feeding	maternal age	delivery	birth order
A	female	68	breast feeding	28	normal	second
B	male	67	supplemented	26	〃	first
C	female	67	〃	26	〃	twins
D	female	67	〃	4	〃	twins
E	female	75	formula	30	caesarean	first
F	female	46	breast feeding	27	normal	second
G	female	60	〃	27	〃	〃
H	male	52	〃	28	〃	first

table 2

	Infant			Mother			correlation coefficiency between Infant & Mother
	Mean S.D.	Median	Range	Mean S.D.	Median	Range	
Fundamental frequency(Hz)	317.5 69.5	310.7	41.8 464.6	278.3 67.0	322.6	180.6 381.8	0.87 (P<0.01)
Duration(sec.)	0.44 0.09	0.40	0.23 0.59	0.69 0.30	0.83	0.28 1.09	−0.09
Latency(sec.)	1.15 0.91	0.80	0.32 2.73	3.32 4.53	0.76	0.38 112.63	0.55 (P<0.2)

Fig. 1 Procedure for calculation of the mean fundamental frequency. The fundamental frequency of this utterance was obtained by areraging the Fo at the four points, A, B, C and D.

A : onset of the utterance
B : minimum pitch
C : maximum pitch
D : offset of the utterance

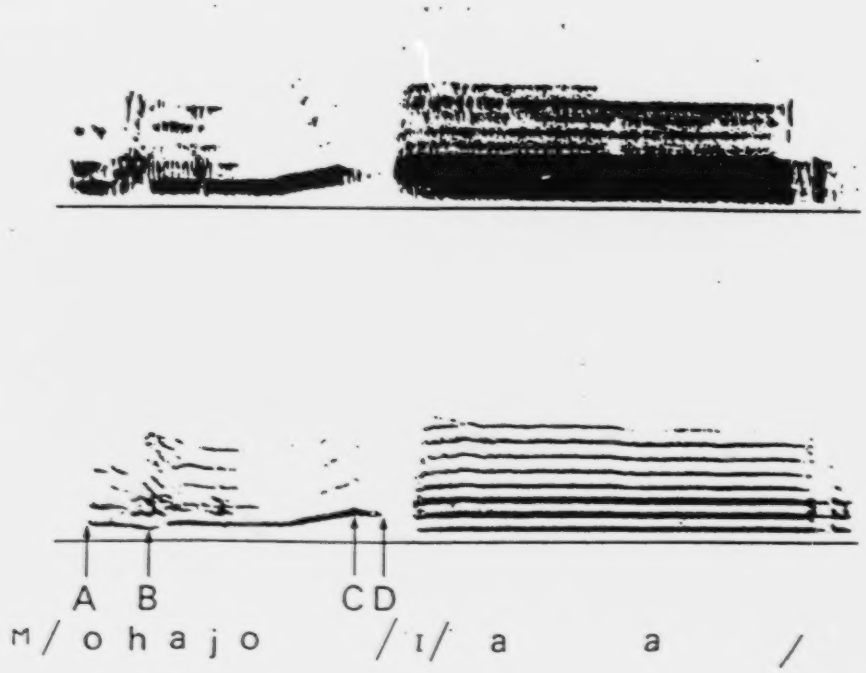

table 3

melody type	fo pattern
rising type	rising
	falling-rising
	rising-falling-rising
falling type	falling
	rising-falling
	falling-rising-falling
flat type	flat
unclassified	

table 4

(%)

melody type	infant*	mother**
rising	6	28
falling-rising	3	3
rising-falling-rising	3	4
rising type	12	35
falling	20	15
rising-falling	35	13
falling-rising-falling	1	2
falling type	56	30
flat type	27	36
unclassified	2	0

(* represents percentage of the 201 analyzed phonetic sounds uttered by the eight infants, while ** represents percentage of the 196 analyzed phonetic sounds uttered by the eight mothers)

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